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Interregional Inequalities in Russia in the Context of Nature Use and Climate Changes

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This paper examines the interregional inequality in Russia. For this study, the Gini coefficient, Theil entropy index, Atkinson index and Moran's index are used to measure the degree of inequality in distribution of monetary income and environmental pressure, such as solid waste generation, atmosphere pollutant emissions and sewage water.
Calculation of inequalities measures for GRDP, pollutant emissions and sewage water per capita has been carried out for Russian regions between 2000 and 2008. These results show that Gini coefficient and Atkinson index (ε=1) for GRDP per capita grew by 27 % and 34 % accordingly between 2000 and 2008. The Gini coefficient, Theil index and Atkinson index (ε=1) for sewage water per capita grew by 15 %, 27 % and 16 % accordingly between 2000 and 2008. That reveals significant increase of inequality for economic development and environmental intensity between Russian regions over the time period. Some conclusions about the consequences of interregional inequalities and tasks of regional policy are presented in the end part of the paper.

Keywords: Russian regions, interregional inequality, environmental pressure

Introduction

It is obviously that achieved results in development and economic growth may be lost in the time of the current global crisis especially in countries with raw-material oriented economies. The data of World Bank show that about 130-155 million peoples became poor in 2008 (Global Economic Prospects: Commodities at the Crossroads 2009). In addition, this economic crisis leads to reduction in government spending, including social expenditures. This may lead to increase of inequalities between regions of Russian Federation. The consequences of processes connected with the crisis are expected to be more severe in the regions of Eastern Siberia and Far East, rich with natural resources, but without oil and gas and poor with modern industries. There is an empirical evidence, that a lower level of development also implies a larger dependence on climate change. Therefore low-developed eastern Russian regions are expected to suffer more from the possible negative impact on different economic spheres, including local husbandry. At the same time, recent governmental initiatives underline the importance of eastern regions development as a priority for national

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strategies. However developmental lagging and deep inequalities might be substantial obstacle on the way to this goal.

The quality of environment is threatened by problems such as global warming, water pollution, fast decline of forests and desertification in many Russian regions. Inequality in eco-intensity (Environmental quality of growth indicators, 2005) of regional economies is seen as an important contributor to these problems.

In this section we present a brief summary of views from the literature that relate inequality. Traditionally, academic studies in inequality issues have focused on the allocation of income. Although inequalities in income are relatively well studied, comparatively little attention has been paid, to date, to inequalities in consumption of environmental goods and services. There are several studies devoted to explore estimation of non-monetary measures of well-being by standard measures of income inequality (the Gini coefficient and Atkinson index) (White, 2007). For example, Ruitenbeek (Ruitebeek, 1996) used these measures to compare market income distribution and distribution of income which includes the value of ecological functions. Styme и Jackson (Styme, Jackson, 2000) also used traditional methodology for estimation of national sustainable welfare. Similar studies can be performed for distribution analysis across the globe or within a nation.

There are several inequality measures used in comparative studies. We use three such measures in our paper: the Gini coefficient, the Atkinson index and the Theil index.

2. The Gini coefficient as a measure of interregional inequality

Russia as a federal state has 83 subfederal units (regions) with very different economics, social and environmental conditions. There is a great difference between regions in welfare and poverty. The map (see Fig.1) shows spatial allocation of the poverty. It depicts (in percentage) the share of people which have the income below the minimum of subsistence.

The Gini coefficient is a commonly used measure of income inequality, which can be calculate using a Lorenz curve. Table 1 shows Gini coefficient as income distribution metric in Russia and one of subfederal unit (Zabaykalsky Krai in Eastern Siberia).

The table shows that great degree of inequality occurs in the distribution of income. Furthermore, it grew at a quick rate (from 0.395 in 2000 to 0.423 in 2008 for Russia). For comparison one can see the values of coefficient Gini for following countries: Norway – 0.28 in 2008, Sweden – 0.23 in 2005, Germany – 0.27 in 2006 (The Central Intelligence Agency, 2009).

The Gini coefficient, which is annually calculated by Russian Federal State Statistic Service, illustrates level of individual income inequality and it doesn't reflect inequalities in regional development. Comparative analysis of gross domestic regional product (GRDP) per capita dynamics shows significant differences between Russian regions. There are some regions which have GRDP per capita at several times bigger (or lower) than mean value for Russia as a whole. The comparison of main environmental indicators also shows significant differences between Russian regions in the context of environmental pressure. Thus, estimation of inequality for regional development and environmental intensity distribution is, of course, an important task.

We modified the conventional Gini methodology for evaluation of interregional inequalities. Thus, the Russian regions are the "subjects of comparison" in our study instead of individuals in conventional analysis. We use the annual data on GRDP per capita, sewage water, air pollutant emissions, solid waste generation for

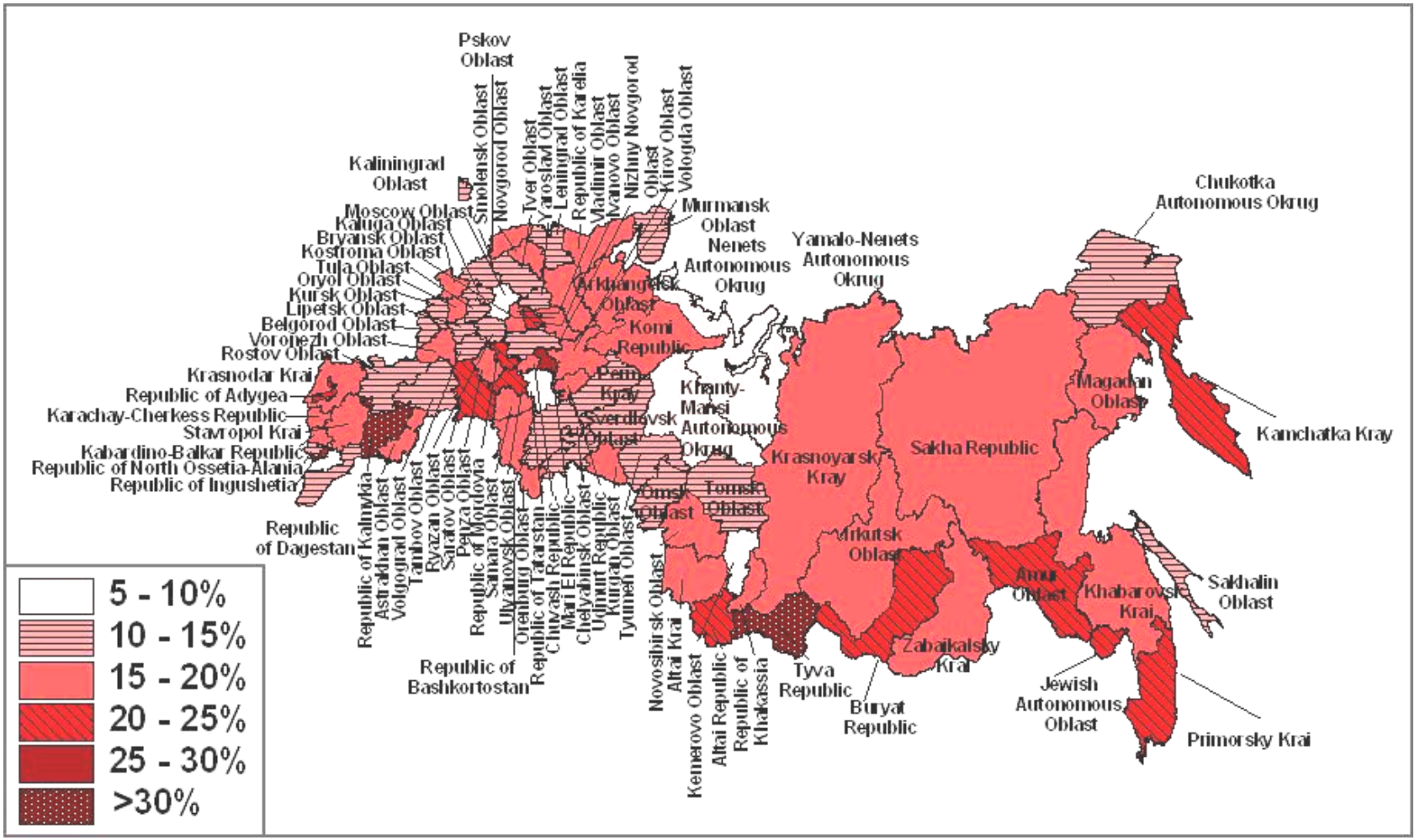

Fig.1 Regional inequality in poverty distribution, 2008. Source: Federal state statistic service of Russia

Table 1. Dynamics of Gini coefficient (income per capita)[1]

Territory \ Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
Russia	0.395	0.397	0.397	0.403	0.409	0.409	0.416	0.423	0.423
Zabaykalsky Krai	0.351	0.331	0.367	0.366	0.372	0.371	0.381	0.389	0.397

[1]. Source: www.gks.ru, 2008

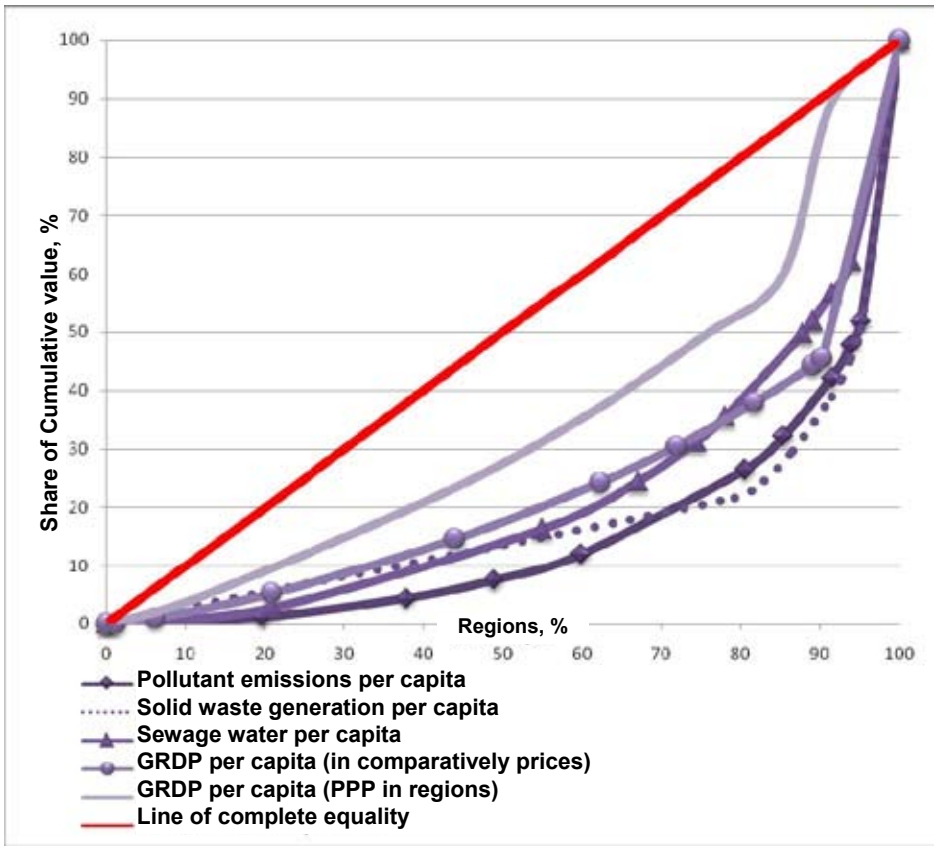

Fig. 2. Lorenz curves for indicators of environmental pressure and GRDP, 2007

the period 2000-2006 as indicators of inequality. The data for our analysis has been obtained from Russian Federal State Statistic Service. Note that waste generation data are not available for some years. To carry out interregional comparison we convert GRDP per capita, taking into account purchasing power parity (PPP) in rubles by comparing price levels in each region relative to the average level in the Russia. The main indicators of environmental pressure were also calculated per capita.

Fig. 2 shows Lorenz curves for indicators of environmental pressure and economic development, 2007. This figure demonstrates that the Lorenz curves keep away from line of the perfect equality, that means what there are essential distinctions in distribution of the negative environmental impact and GRDP among regions of Russia. It should be noted that the same oil-extracting regions are situated in right part of both Lorenz curves: GRDP and atmospheric pollutant emissions.

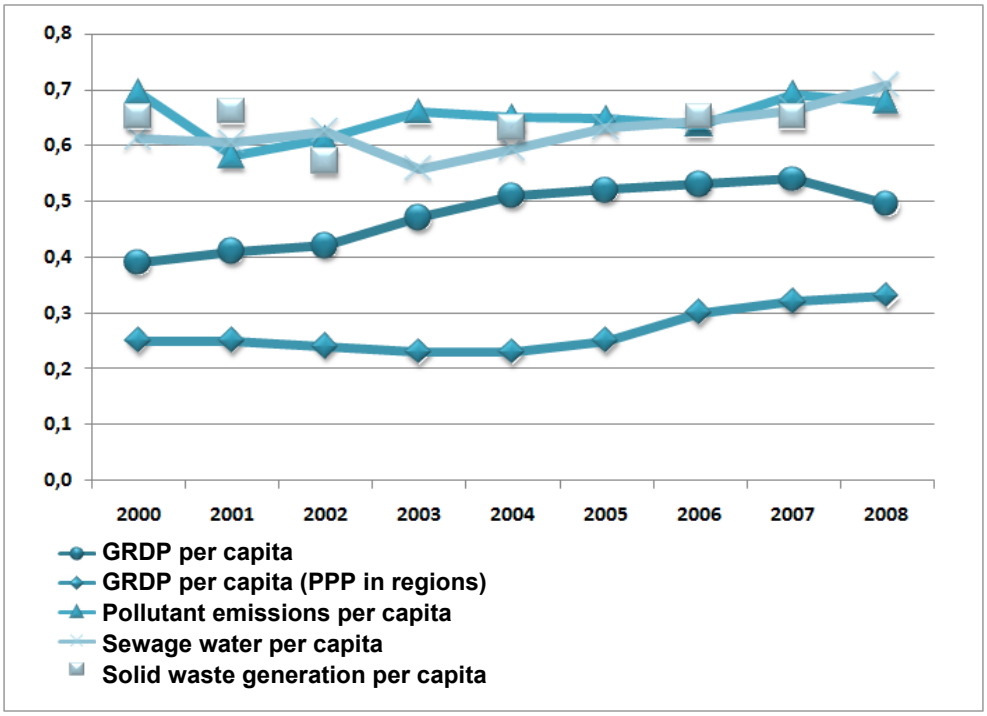

Fig. 3. Dynamics of Gini coefficient for Russian Federation

Dynamics of Lorenz curves shows that divergences from lines of the perfect equality has become more significant during time period 2000-2008. Fig. 3 illustrates dynamic of coefficient Gini over time.

However, to be sure that our conclusion about substantial inequality does not depend on chosen methods of evaluation, we use different tools of the measurement.

3. The Atkinson measure and issues of climate change

A measure of inequality defined by Atkinson is based on function describing social welfare. In spite of this fact, the Atkinson measure can be applied not only for income distribution, but also for other data (in particular for indicators of environmental pressure). It is possible because this index satisfies basic properties which are generally postulated for any measure of inequality (Hedenus, Azar, 2005). The Atkinson index is defined as:

$$I_A = \begin{cases} 1 - \left(\frac{1}{N} \sum_{i=1}^{N} \left(\frac{Y_i}{\overline{Y}} \right)^{1-\varepsilon} \right)^{\frac{1}{1-\varepsilon}}, & \varepsilon \neq 1 \\ 1 - \prod_{i=1}^{N} \left(\frac{Y_i}{\overline{Y}} \right)^{1/n}, & \varepsilon = 1 \end{cases}$$

where, Y_i is the GRDP per capita of region i, N is amount of regions, ε is the inequality aversion parameter.

The choice of the parameter ε which represents society's preference for equality is a specific feature of the Atkinson measure. At the same time, the proper evaluation of this parameter is the most difficult aspect of this method. When ε=0, society is indifferent to equality but the higher value of ε means the higher inequality aversion by society.

Some authors (White, 2007; Kakamu, Fukushige, 2005) use various values of ε to demonstrate how the Atkinson index changes in dependence on society preference. Other (Hedenus, Azar., 2005.) take logarithmic utility

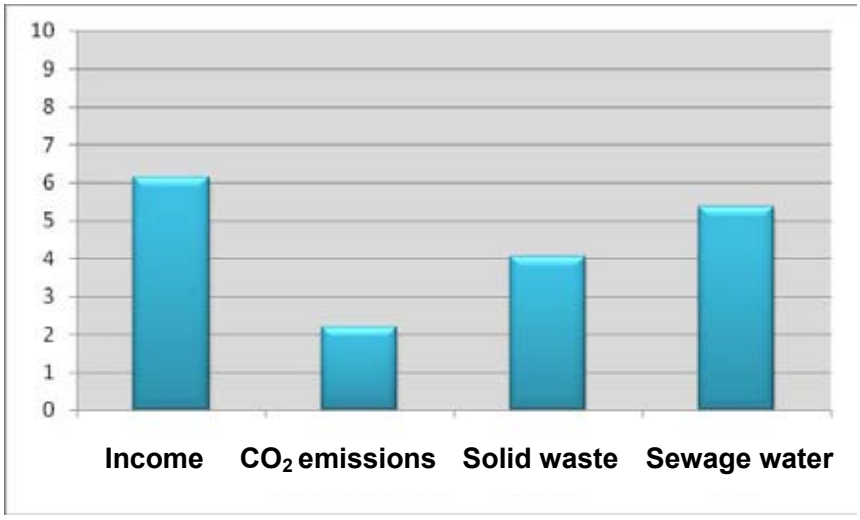

Fig. 4. Expert evaluation of society's preference for equality

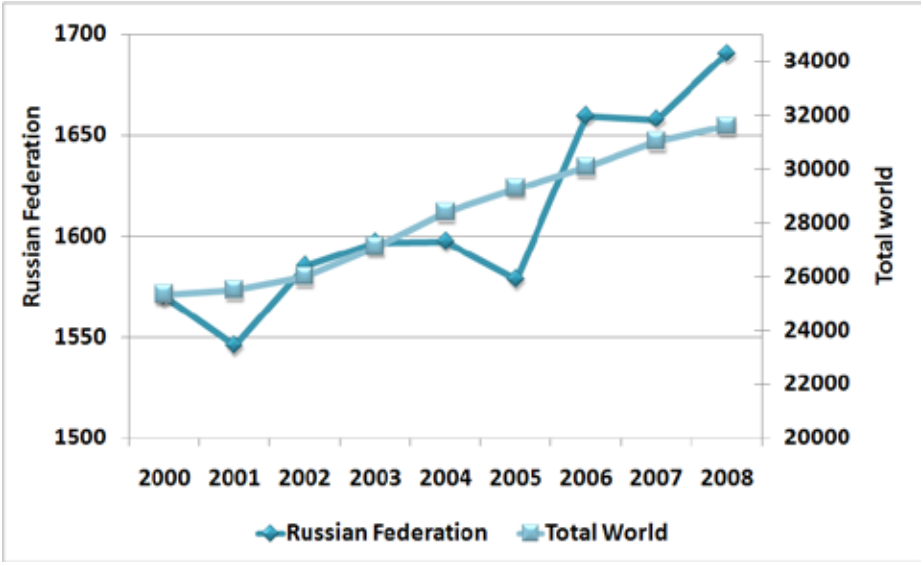

Fig. 5 Dynamics of carbon dioxide emissions, 2000-2008. Source: BP Statistical Review of World Energy, 2009

function (ε =1). For the purpose of defining society's preference for equality in Russia we carried out expert's inquiry based on ten-point scale. These results are shown in Fig. 4.

So, we can conclude that Russian society holds an interest not only in distribution of income, but in allocation of environmental pressure. Atkinson indices were calculated for such kind atmospheric pollutant as carbon dioxide. It reflects that society is more worried by emissions greenhouse gases in comparison with other pollutants and its influences on global climate changes. Trends of carbon dioxide emissions from consumption of oil, gas and coal are shown on Fig. 5.

Figure 5 shows stable increasing of CO_2 emissions in the World and significant growth of this indicator in Russia during last years. In sprite of different points of view on climate change problem, the trend of temperature change roses at last 30 years (Fig. 6). Long term trends (1976-2006) indicate increase on 0.18°C/10 years for global surface air temperature but for territory of

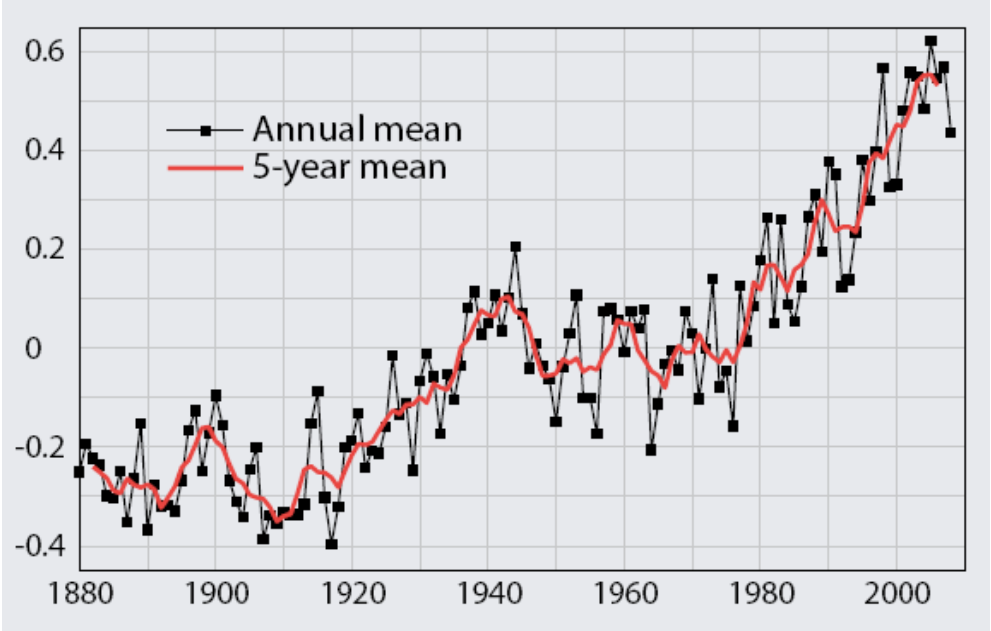

Fig. 6 Global surface air temperature change. The period 1951-1980 is used as the baseline. Source: GISS (2009b); UNEP Year book, 2010

Russia it is more significant – 0.43°C/ 10 years (Report about climate features on the Russian territory 2006). Recent estimates show that these rates are increasing permanently.

So, the estimation of Atkinson index also shows significant inequality in distribution of economic performance and environmental pressure. Dynamics of Atkinson measure is illustrated on Fig. 7 (for the case when ε =1) and Fig. 8 (for case when ε was estimated by experts).

4. The Theil index and issues of interregional spatial interaction

The Theil index (with 1 or 2 indicators) is based on information entropy concept and it is traditionally used for estimation of inequality. One of the variants of the Theil index may be defined by the formula:

$$I_T = \sum_{i=1}^{N} \frac{Y_i}{Y} \ln \frac{Y_i / P_i}{Y / P}$$

Where Y_i is the GRDP of region i, N is the number of regions, P_i is the population of region i, P is total population, Y is total income (Theil, 1967).

The operation $1 - e^{-T}$ is to be done to converse it values in the interval [0, 1]. The result of the conversion is called normalized Theil index. Fig. 9 presents dynamics of normalized Theil indices for Russian regions.

Thus, the Theil indices rose for all considering indicators, waste generation excepted. It means increasing of interregional inequality in distribution of economic performance and environmental pressure which is more obviously for air pollutant emissions per capita.

All above-mentioned indexes and coefficients allow to measure existing inequality but do not take into account influence of region on each other. Such factors as free labor resources, large-scale industrial enterprises and stocks of natural resources, high values of productivity of labor and investment activities, GRDP growth rates, developed road network and many other factors in

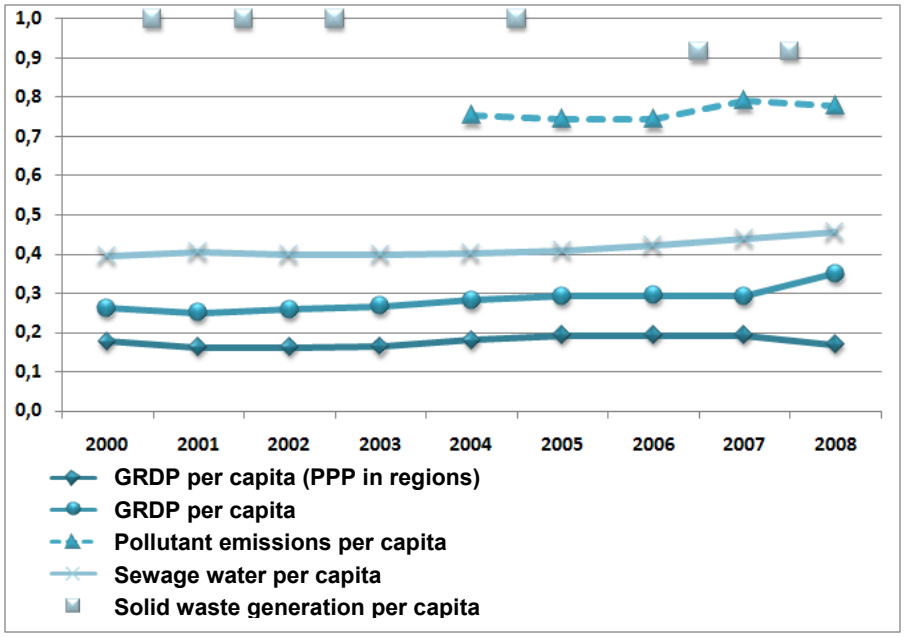

Fig. 7. Dynamics of Atkinson indexes (ε=1) for Russian Federation

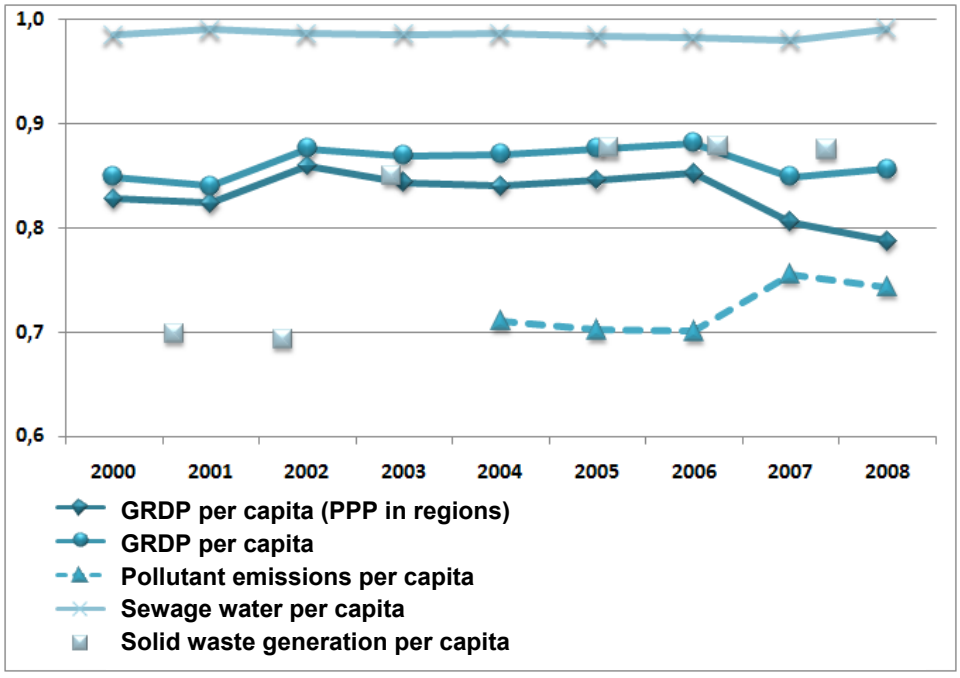

Fig. 8. Dynamics of Atkinson indexes (ε was estimated by experts) for Russian Federation

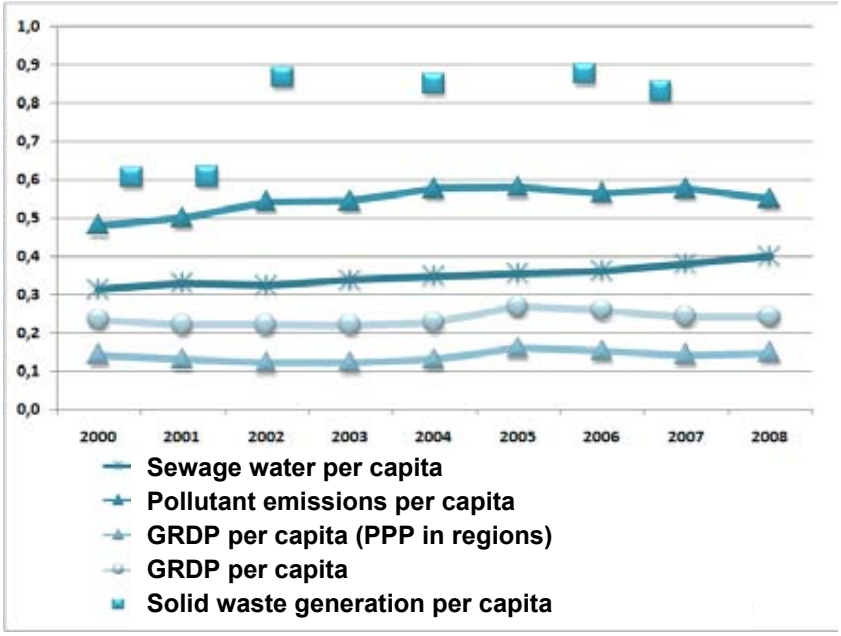

Fig. 9. Dynamics of normalized Theil indices for Russian Federation

nearest regions may or may not provide economic performance of another region and moreover may lead to its environmental degradation. So, considered indicators can be cause by interregional spatial interaction (Lugovoy, 2007).

The Moran's index is one of the indicators which is used to estimate spatial autocorrelation. It is defined as:

$$I_M = \frac{N}{\sum_i \sum_j w_{ij}} \frac{\sum_i \sum_j w_{ij}(x_i - \mu)(x_j - \mu)}{\sum_i (x_i - \mu)^2}$$

where, N is amount of regions, w_{ij} is element of contiguity matrix for regions i and j, μ is mean value of indicator, x – value of indicator.

The Moran's index is shown in table 2. For 82 regions expected value of index E(I) is – 0,012. In the case of I_M>E(I) we have positive spatial autocorrelation of studied processes. More essential correlation reveals for economic performance and air pollutant emissions in Russia.

5. Conclusions: inequality and the crisis

There are several results what indicate increasing of inequality in distributions of income and environmental pollutions between Russian regions. First, the Gini coefficient and Atkinson index (ε=1) for GRDP per capita grew by 27 % and 34 % accordingly between 2000 and 2008. This means that level of inequality for well-being between regions rose over the time period. Second, level of interregional inequality for environmental pressure grew also. So, the Gini coefficient, Theil index and Atkinson index (ε=1) for sewage water per capita grew by 15 %, 27 % and 16 % accordingly between 2000 and 2008. At the same time the results show increasing of inequality in distribution of air pollutant emission (Theil index grew by 15 %) and waste generation (Theil index and Atkinson Index (ε=1) grew by 37 % и 25 % accordingly). Third, generally environmental intensity exhibits higher levels of inequality than income per capita.

Table 2. Moran's Index for the indicators of Russian regions[1]

Indicator	Moran's Index
GRDP per capita	0.002
GRDP per capita (PPP in regions)	0.28
Pollutant emissions per capita	0.35
Sewage water per capita	0.01
Solid waste generation per capita[2]	0.13

[1] Source: www.gks.ru, 2008
[2] Source: www.gks.ru, 2007

Table 3. Inequality metrics for the indicators of Russian regions[1]

Inequality metrics / Indicator	Gini coefficient	Atkinson index (ε=1)	Atkinson index	Normalized Theil Index
GRDP per capita	0.5	0.35	0.86	0.24
GRDP per capita (PPP in regions)	0.33	0.17	0.79	0.15
Pollutant emissions per capita	0.68	0.78[2]	0.74[2]	0.55
Sewage water per capita	0.71	0.46	0.99	0.40
Solid waste generation per capita[3]	0.65	0.92	0.88	0.83

[1] Source: www.gks.ru, 2008
[2] Evaluated by CO2 emissions
[3] Source: www.gks.ru, 2007

Increasing inequalities in distribution of environmental intensity may be the reflection of so called environmental colonialism policy (Brookfield, 1992) in relation to some Russian regions. Environmental colonialism may reveals in extraction of natural resources with the use of outdated polluting technologies (if beneficiaries are not residents of the region), export of raw materials, import of environmentally dangerous products etc.. It can force the danger of interregional and interpersonal pressure and even conflicts and lead both to economic and the social crisis. In addition in future this aspect may be the factor of political instability (Smyshliaev, 2005). In order to demonstrate the current values of inequalities we collect all data in Table 3.

Economic development of Russian Federation (2000-2008) was characterized by permanent growth (Fig. 10) but it was not equity in time and spatial. The first appearance of crisis in Russia took place at August – September 2008 and it led to downfall of GDP growth rate in 2009 like other countries.

It should be noted that the first results of the crisis (2008) had effect on interregional inequality reduction. All considered indexes show decrease of inequality in distribution of air pollutant emissions (1.5-4.7 %) and generally in distribution of economic performance (2.3-12.3 %).

In sprite of declared goals of the development based on innovations, economies of many Russian regions are still raw-material oriented. New recent large projects in Eastern Siberia and Russian Far East mainly connected with natural resources extraction and export of raw materials (The Program-2018). Irreversible changes in ecosystems and the depletion of natural capital

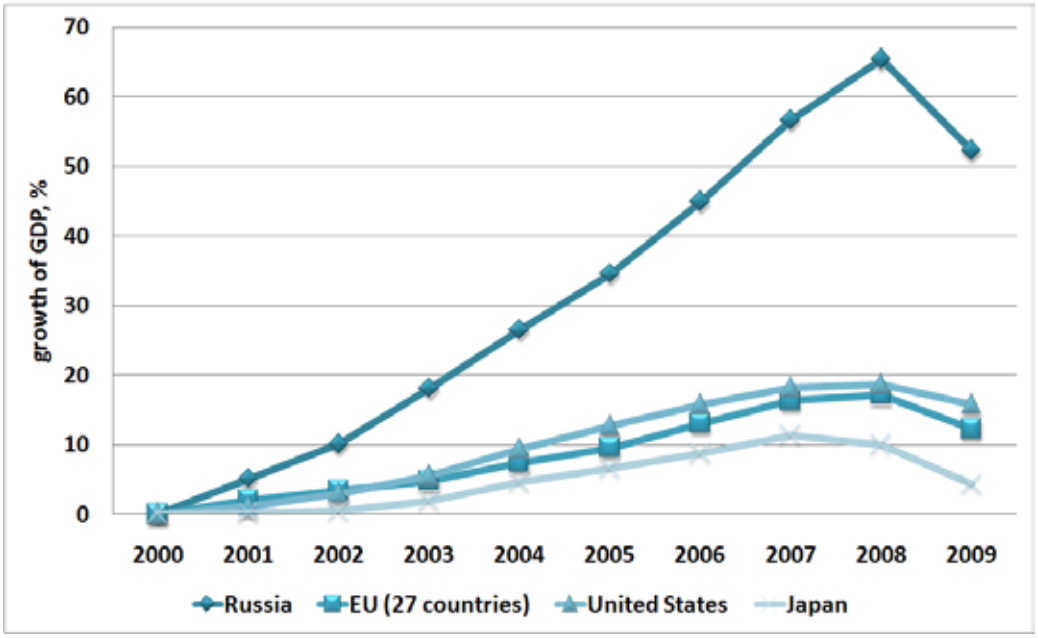

Fig. 10. Decrease of GDP Growth (based on 2000 GDP) in time of the crisis. Source: Eurostat, Federal state statistic service of Russia

(Glazyrina, 2001) decrease the opportunity for environmentally sound diversification of the regional economies. It also inevitably impacts of the quality of life in eastern regions. Existing level of inequality carries a potential of the negative influence on the development of the entire country.. In the long-term aspect the inequalities will foster a relocation of labor resources (mainly, high-skilled) to the regions with higher development and better environment. There is an apprehension that the observed resettlement of population from Siberia and Far East will go on together with comparative decline in living standards in these regions. It might result in relocation of investment flows and, ultimately, in the further increase in interregional and social inequalities. For the border regions it means also the losses in the competition with North East provinces of the fast-growing China. The total dependence of regional economies on the factors of Chinese influence might be the unavoidable consequence. Thus, an overcoming or at least the reduction of interregional inequality is the key task of Russian regional policy.

6. Acknowledgments

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Межрегиональное неравенство в России в контексте природопользования и климатических изменений

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Данная статья исследует межрегиональное неравенство в России при помощи коэффициента Джини, индекса энтропии Тейла, индексов Аткинсона и Морана. Перечисленные показатели использовались для измерения степени неравномерности распределения денежных доходов и экологической нагрузки (образование твердых бытовых отходов, загрязнение атмосферы и выброс сточных вод).

Представлены результаты вычисления мер неравенства для ВРП, выброса загрязняющих веществ и сточных вод на душу населения для российских регионов в период с 2000 по 2008 гг. Оценки показывают, что коэффициенты Джини и Аткинсона (ε=1) для ВРП на душу населения возросли на 27 % и 34 % соответственно с 2000 по 2008 гг. Коэффициент Джини, индексы Тейла и Аткинсона (ε=1) для сброса сточных вод возросли на 15 %, 27 % и 16 % соответственно с 2000 по 2008 гг. Эти факты демонстрируют возрастание неравенства экономического развития и интенсивности истощения природной среды между российскими регионами в течение рассматриваемого периода. В конце статьи представлена оригинальная точка зрения на последствия увеличения межрегионального неравенства, а также предложены задачи по корректировке сложившегося положения со стороны представителей региональных властей.

Ключевые слова: российские регионы, межрегиональное неравенство, экологическая нагрузка.